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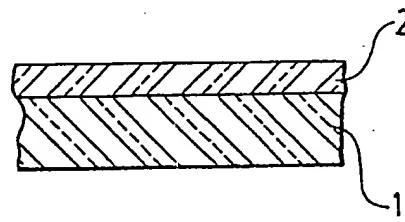
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(54) Optical recording medium and the method of recording, reading, and erasing information using it.

(57) The invention provides an optical recording medium and a method of recording, reading, and erasing information to an optical recording medium, where information is recorded, read, and erased to the recording medium by applying beams projected from a light source capable of varying wavelength of beams. The recording medium contains at least two kinds of organic compounds each presenting photochromic phenomenon and being dispersed in binder. By projecting beams onto the optical recording medium, recording, reading, and erasure of information making use of a photochromic phenomenon can be executed independently against each organic compound dispersed in the recording medium. As a result, the optical recording medium promotes to increase the information recording density in proportion to the number of the kind of organic compounds.

FIG. 2



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Description**OPTICAL RECORDING MEDIUM AND THE METHOD OF RECORDING, READING, AND ERASING INFORMATION USING IT****FIELD OF THE INVENTION**

The present invention relates to an optical recording medium by which information is recorded, read and erased by applying laser beams for example making use of the photochromic phenomenon and the method thereof.

BACKGROUND OF THE INVENTION

Recently, as a result of the achievement of high density and large capacity, the demand for optical recording medium tends to significantly grow year by year. Conventionally, optical recording medium is classified into three kinds according to the state of use including the one which is solely used for reading, the one which allows additional recording (write once-type), and the other one which allows rewriting of information, respectively.

Of these, the write once-type optical recording medium is to be recorded information by applying such processes consisting essentially of the projection of laser beams onto the recording medium of the optical recording medium and the occurrence of fusion or decomposition of the beam-projected spot for providing geometric pits in the beam-projected recording medium.

Besides above example, information can also be recorded in the write once-type optical recording medium by applying those processes consisting essentially of the projection of laser beams onto the recording medium of the optical recording medium and the variation of optical characteristic like the index of reflection of the beam-projected portion by crystallizing or forming non-crystalline condition of the beam-projected portion so that information can be recorded.

Conventionally, there is such a rewritable optical recording medium in which information is recorded making use of a magneto-optical effect or a phase transition of a recording medium. Information is recorded by using the optical recording medium applying a magneto-optical effect by sequentially executing those processes described below. First, laser beams are projected onto a recording medium containing films which are magnetized in a direction perpendicular to the surface of the recording medium. Next, by applying a magnetic field from external source, the magnetized direction of the magnetized portion is inverted from that of the portion in which is not exposed to the projection of beams in the condition where the beam-projected portion is heated above the Curie temperature, thus allowing the rewritable optical recording medium to be recorded information.

While information is recorded by using the optical recording medium applying a phase transition by

executing those processes described below.

5 First, laser beams are projected onto the recording medium, and then, a phase of the beam-projected portion of the recording medium is converted into a crystalline condition from the non-crystalline condition or vice versa, thereby recording information in the optical recording medium. Note that any of those methods mentioned above for recording information in the optical recording medium uses laser beams as a heating source, and thus, these processes can be summarized into a "heat-mode" recording system.

10 Recently, independent of the "heat-mode" recording system, research and development of such an optical recording medium using the "photon-mode" recording system are positively followed up. As a typical example of the "photon-mode" recording system, such an art using organic compound presenting photochromic phenomenon is conventionally known. For example, as was disclosed by the Japanese Laid-Open Patent Publication No. 62-165751 (1987), information is recorded on the multiplex basis according to the wavelength dimensions and the polarization-degree dimensions on a recording spot of laser beams by initially writing information in a cumulative film cumulated with a plurality of monomolecular films containing organic coloring matter on recording medium by projecting beams having different wavelengths or degree of polarization, followed by varying either the wavelengths or the degree of polarization of laser beams used for recording.

15 The photochromic phenomenon is the phenomenon in which a certain solid or liquid material reversibly varies in color by projecting a light. There are a wide variety of organic compounds which present a photochromic phenomenon such as hydrazone, osazone, stilbene, salicylaldehyde, spiro-pyrane, fulgide, azobenzene, and derivatives of these, for example. Out of these organic compounds, a typical example of optical recording medium using well-known recording medium composed of fulgide is cited below. By projection of ultraviolet rays having a wavelength of about 340nm and visible rays, fulgide alternately causes intramolecular ring closure as shown in FIG. 3 (b) and the intramolecular ring open as shown in FIG. 3 (a). As a result, as is well known, variation of the absorption spectrum shown by the solid line and the assumptive line in FIG. 4 reversibly occurs.

20 For example, the absorption spectrum shown by solid line in FIG. 4 is initially caused by preliminarily projecting visible rays onto fulgide, followed by execution of the recording by projecting recording beams having a wavelength of about 340nm thereon. The portion exposed to the projection of the recording beam varies into the state indicated by the absorption spectrum shown by the assumptive line in FIG. 4. As a result, for example, when this portion is subjected to the projection of weak beams having

a wavelength of about 350nm close to the wavelength of the recording beam, a certain difference in absorbance shown by ΔT in FIG. 4 is produced between the portion subjected to the projection of the recording beam and the portion free from the beam projection, and thus, based on the difference in absorbance, a recorded signal can be read.

On the other hand, in order to erase the recorded signal, the absorption spectrum shown by solid line I in FIG. 4 restores itself as a result of the projection of beams having a wavelength of about 500nm onto the portion subjected to the projection of the recording beam. As mentioned above, since the photochromic phenomenon is reversibly presented, the recording medium can be used for an erasable optical recording medium.

In the manner mentioned above, recording information in the optical recording medium making use of a photochromic phenomenon is implemented by projecting laser beams onto the recording medium. On the other hand, the spot diameter of beams focused by the optical lens is constrained by the diffraction, where the spot diameter is confined to the scope of the wavelength. Actually, the spot diameter of visible rays or near-infrared rays is confined to about one micron. When executing digital recording of one-bit information in the beam-spot region, any of those conventional optical recording media is merely provided with a maximum of 10^8 bit/cm² of recording density, and as a result, sufficient recording density cannot be provided for any conventional optical recording medium.

In order to more densely record information using a photon-mode recording system, recently, research and development of newer optical recording media making use of a photochemical hole burning phenomenon are positively underway. Nevertheless, actually, there are still a variety of technical problems to solve before offering them for practical use.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an optical recording medium in which at least two kinds of organic compounds each showing photochromic phenomenon are dispersed in a binder so that information can be independently recorded, read and erased by the optical recording medium making use of the photochromic phenomenon of each organic compound.

Another object of the invention is to provide an optical recording medium by which an information recording density can be increased in proportion to the number of the kind of organic compounds.

A still further object of the invention is to provide the method of recording, reading, and erasing information using the aforementioned optical recording medium.

To achieve these objects mentioned above, an optical recording medium by which information is recorded, read, and erased to a recording medium by applying beams projected from a light source capable of varying wavelength, wherein the recording medium comprises at least two kinds of organic

compounds individually presenting a photochromic phenomenon being dispersed in a binder.

The aforementioned optical recording medium may include a substrate made of glass or plastic or the like material and a recording medium formed on the substrate.

The optical recording medium mentioned above may include at least two kinds of organic compounds such as hydrazone, osazone, stilbene, salicylaldehyde, spiropryan, fulgide, azobenzene, and derivatives of these, being dispersed in the binder.

The above optical recording medium may include thioindigo and pyrene thioindigo being dispersed in the binder.

The binder mentioned above may keep at least two kinds of organic compounds in a dispersed condition and may include an optically transparent material.

The above binder may be made of acrylic polymer, or polyvinyl chloride polymer, or inorganic compound such as water glass.

The organic compound mentioned above may have their color which is reversibly variable by a projection of beam from a light source which is capable of projecting beams having different wavelengths.

The above organic compound may have an absorption spectrum which is reversibly and significantly variable by a projection of beams from the light source which is capable of projecting beams having different wavelengths.

The substrate mentioned above may comprise geometric pattern such as grooves etc. on the surface thereof.

The above recording medium may be formed a reflection film on the top surface thereof.

The above recording medium may comprise protective films by which the recording medium is disposed therebetween, whereby the recording medium can be protected from high temperature and humidity.

A method of recording, reading, and erasing information to the optical recording medium mentioned above comprises the steps:

an initial step for producing the first absorption spectrum by projection of beams having such a wavelength corresponding to the point close to the peak of the second absorption spectrum onto organic compounds each presenting a photochromic phenomenon in which the first and second absorption spectra reversibly vary by exposure to the projection of beams having different wavelengths;

a recording step for recording information in the recording medium by projection of the recording beams having a wavelength corresponding to the point close to the peak of the first absorption spectrum onto the recording medium;

a reading step for reading information from the recording medium by the detection of the difference in absorbance between the absorption spectra before and after recording with recording beams by projecting beams having such a wavelength corresponding to the point close to the recording beam

and lower intensity than that of the recording beams; and
an erasing step for erasing the recorded information by projecting beam having such a wavelength corresponding to the point close to the peak of the second absorption spectrum onto the recording medium, followed by varying the second absorption spectrum of the recorded portion into the first absorption spectrum so that the condition of the recording medium is in an initial state.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 respectively show an embodiment of the present invention wherein;

FIG. 1 (a) is a graphical chart illustrating an absorption spectrum of organic compound A in a recording medium of an optical recording medium;

FIG. 1 (b) is a graphical chart illustrating an absorption spectrum of organic compound B in a recording medium of an optical recording medium;

FIGS. 1 (c) and (d) are graphical charts illustrating whole absorption spectra in a recording medium of an optical recording medium; and

FIG. 2 is a partly diagrammatic longitudinal sectional view of an optical recording medium.

FIGS. 3 and 4 respectively show a recording medium of a conventional optical recording medium wherein;

FIG. 3 (a) is a structural formula illustrating a condition of ring open of fulgide used for component of a recording medium of a conventional optical recording medium;

FIG. 3 (b) is a structural formula illustrating a condition of ring closure of fulgide used for component of a recording medium of a conventional optical recording medium; and

FIG. 4 is a graphical chart illustrating a variation of the absorption spectrum produced by fulgide used for component of a recording medium shown in FIGS. 3 (a) and (b).

DESCRIPTION OF THE EMBODIMENTS

Referring now to Figures 1 and 2, an embodiment of an optical recording medium according to the present invention will be explained hereinbelow.

As shown in FIG. 2, an optical recording medium is composed of a substrate 1 made of glass or plastic or the like and a recording medium 2 formed on the substrate 1. The recording medium 2 has a composition in which at least two kinds of a variety of organic compounds presenting a photochromic phenomenon such as hydrazone, osazone, stilbene, salicylaldehyde, spiropyrane, fulgide, azobenzene, and derivatives of these, are dispersed in a binder.

The binder can hold at least two kinds of organic compounds in a dispersed condition, and yet, such binder which is optically transparent is acceptable

for use. For example, acrylic polymer of polyvinyl chloride polymer, or inorganic material such as water glass may also be used for the binder.

The following description refers to the case in which the recording medium 2 contains two kinds of organic compounds A and B each presenting a photochromic phenomenon in the condition where they are dispersed in the binder for example.

The example will be described under the following condition. That is, as shown in FIG. 1 (a), organic compound A presents a photochromic phenomenon on exposure to beams having wavelengths λ_1 and λ_2 , where the absorption spectrum thereof reversibly varies between the condition indicated by the solid line i and the other condition indicated by the assumptive line ii. On the other hand, as shown in FIG. 1 (b), organic compound B presents a photochromic phenomenon on exposure to beams having wavelengths λ_3 and λ_4 , where the absorption spectrum thereof reversibly varies between the conditions indicated by the solid line i and the assumptive line ii. The embodiment adopts such organic compounds A and B which respectively have the recording and erasing wavelengths λ_1 through λ_4 used for recording and erasing information on and from those organic compounds A and B, therein each wavelength having the relationship $\lambda_1 < \lambda_2 < \lambda_3 < \lambda_4$ therebetween.

In order to record information in the recording medium 2, first, the recording medium 2 is exposed to the sequential projection of beams having wavelengths λ_2 and λ_3 during an initial stage, and then the absorption spectrum indicated by the solid line i in FIG. 1 (c) is preserved in the recording medium 2.

Then, when projecting a recording beam having wavelength λ_1 onto the recording medium 2, only the organic compound A in the recording medium 2 takes place photochemical reaction, and then the absorption spectrum of the organic compound A varies into that shown by the assumptive line ii in FIG. 1 (c). When projecting a beam having lower intensity than that of the recording beam and wavelength close to λ_1 in the above condition, there occurs, the difference in absorbance ΔT between the absorption spectra before and after the recording with the recording beam having wavelength λ_1 , whereby recording information using wavelength λ_1 can be detected.

Next, when projecting a recording beam having wavelength λ_4 onto the recording medium 2 in the condition where the organic compound A has the absorption spectrum shown by the assumptive line ii in FIG. 1 (c), only the organic compound B takes place photochemical reaction, and then the absorption spectrum of the organic compound B varies into that shown by the assumptive line ii in FIG. 1 (d). When projecting a beam having lower intensity than that of the recording beam and wavelength close to λ_4 in the above condition, there occurs, the difference in absorbance between the absorption spectra before and after the recording with the recording beam having wavelength λ_4 , whereby recording information using wavelength λ_4 can be detected. In this way, recordings with wavelengths

λ_1 and λ_4 are independently executed without adversely affecting the content of the previous recordings done with other wavelength.

For example, in order to erase information recorded by the recording beam having wavelength λ_1 in the condition where the organic compound A has the absorption spectrum shown by the assumptive line II, when a beam having wavelength λ_2 is projected onto the recording medium 2, the absorption spectrum returns to the condition shown by the solid line I. In this way, irrespective of the previous recording done by applying other wavelengths, additional recording using wavelengths λ_1 and λ_4 can be respectively executed independently. Furthermore, erasure of the recorded information by applying respective wavelengths λ_1 and λ_4 can be executed independently without adversely affecting the content of information recorded by applying other wavelengths. Accordingly, the optical recording medium according to the present invention provides information recording capacity which is doubled in comparison with that of any conventional optical recording medium using a single kind of organic compound.

As a typical embodiment of the combination of organic compounds A and B, it is suggested to use thioindigo (having a wavelength λ_1 of about 490nm and a wavelength λ_2 of about 540nm) and pyrene thioindigo (having a wavelength λ_3 of about 580nm and a wavelength λ_4 of about 720nm). However, a wide variety of other combinations of organic compounds A and B may also be used, which have different wavelengths of beams when presenting a photochromic phenomenon.

The above embodiment uses two kinds of organic compounds dispersed in the binder. However, the embodiment also allows the combination of three or more kinds of organic compounds provided that multiplex recording can be executed based on the principle mentioned above.

As mentioned above, an optical recording medium according to the present invention by which information is recorded, read, and erased to a recording medium by applying beams projected from a light source capable of varying wavelength, wherein the recording medium comprises at least two kinds of organic compounds individually presenting a photochromic phenomenon being dispersed in a binder.

The aforementioned optical recording medium may include a substrate made of glass or plastic or the like material and a recording medium formed on the substrate.

The optical recording medium mentioned above may include at least two kinds of organic compounds such as hydrazone, osazone, stilbene, salicylaldehyde, spiroprylane, fulgide, azobenzene, and derivatives of these, being dispersed in the binder.

The above optical recording medium may include thioindigo and pyrene thioindigo being dispersed in the binder.

The binder mentioned above may keep at least two kinds of organic compounds in a dispersed condition and may include an optically transparent material.

The above binder may be made of acrylic polymer, or polyvinyl chloride polymer, or inorganic compound such as water glass.

5 The organic compound mentioned above may have their color which is reversibly variable by a projection of beam from a light source which is capable of projecting beams having different wavelengths.

10 The above organic compound may have an absorption spectrum which is reversibly and significantly variable by a projection of beams from the light source which is capable of projecting beams having different wavelengths.

15 The substrate mentioned above may comprise geometric pattern such as grooves etc. on the surface thereof.

The above recording medium may be formed a reflection film on the top surface thereof.

20 The above recording medium may comprise protective films by which the recording medium is disposed therebetween, whereby the recording medium can be protected from high temperature and humidity.

25 A method of recording, reading, and erasing information to the optical recording medium mentioned above comprises the steps:

an initial step for producing the first absorption spectrum by projection of beams having such a wavelength corresponding to the point close to the peak of the second absorption spectrum onto organic compounds each presenting a photochromic phenomenon in which the first and second absorption spectra reversibly vary by exposure to the projection of beams having different wavelengths;

30 a recording step for recording information in the recording medium by projection of the recording beams having a wavelength corresponding to the point close to the peak of the first absorption spectrum onto the recording medium;

35 a reading step for reading information from the recording medium by the detection of the difference in absorbance between the absorption spectra before and after recording with recording beams by projecting beams having such a wavelength corresponding to the point close to the recording beam and lower intensity than that of the recording beams; and

40 an erasing step for erasing the recorded information by projecting beam having such a wavelength corresponding to the point close to the peak of the second absorption spectrum onto the recording medium, followed by varying the second absorption spectrum of the recorded portion into the first absorption spectrum so that the condition of the recording medium is in an initial state.

45 By virtue of those features mentioned above, making use of a photochromic phenomenon, recording, reading, and erasure of information can be executed independently to the individual organic compounds dispersed in the recording medium. As a result, the optical recording medium according to the present invention significantly promotes information recording density in proportion to the number of the kind of organic compounds.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention.

There are described above novel features which the skilled man will appreciate give rise to advantages. These are each independent aspects of the invention to be covered by the present application, irrespective of whether or not they are included within the scope of the following claims.

Claims

1. An optical recording medium by which information is recorded, read, and erased to a recording medium by applying beams projected from a light source capable of varying wavelength, wherein said recording medium comprises at least two kinds of organic compounds each presenting photochromic phenomenon being dispersed in a binder.

2. An optical recording medium according to claim 1 comprises a substrate made of glass or plastic or the like and a recording medium formed on said substrate.

3. An optical recording medium according to claim 1, wherein at least two kinds of organic compounds such as hydrazone, osazone, stilbene, salicylaldehyde, spiroprane, fulgide, azobenzene, and derivatives of these, are dispersed in said binder.

4. An optical recording medium according to claim 1, wherein thioindigo and pyrene thioindigo are dispersed in said binder.

5. A binder of claim 1 which keeps at least two kinds of organic compounds in a dispersed condition and comprises a certain material which is optically transparent.

6. A binder of claim 1 which is composed of acrylic polymer, or polyvinyl chloride polymer, or inorganic compound such as water glass.

7. An organic compound according to claim 1, wherein color of said organic compound is reversibly variable by beam projected from a light source which is capable of projecting beams having different wavelengths from each other.

8. An organic compound according to claim 1, wherein the absorption spectrum of said organic compound reversibly and significantly varies itself on exposure to beam projected from a light source which is capable of projecting beams having different wavelength from each other.

9. A substrate of claim 2 which comprises geometric pattern such as grooves on the surface thereof.

10. A recording medium of claim 2 which is formed a reflection film on the top surface thereof.

11. A recording medium according to claim 2 comprises protective films by which said recording medium is disposed therebetween, whereby the recording medium can be pro-

tected from high temperature and humidity.

12. A method of recording, reading, and erasing information to an optical recording medium comprises the steps:

an initial step for producing the first absorption spectrum by projection of beams having a wavelength corresponding to the point close to the peak of the second absorption spectrum onto organic compounds each presenting a photochromic phenomenon in which the first and second absorption spectra reversibly vary by exposure to the projection of beams having wavelengths different from each other;

a recording step for recording information in said recording medium by projection of the recording beams having a wavelength corresponding to the point close to the peak of the first absorption spectrum onto said recording medium;

a reading step for reading information from said recording medium by the detection of the difference in absorbance between the absorption spectra before and after recording with recording beams by projecting beams having such a wavelength corresponding to the point close to said recording beams and lower intensity than that of said recording beams; and

an erasing step for erasing said recorded information by projecting beam having such a wavelength corresponding to the point close to the peak of said second absorption spectrum onto said recording medium, followed by varying said second absorption spectrum of the recorded portion into said first absorption spectrum so that the condition of said recording medium is in an initial state.

13. A photochromic optical recording medium which includes a recording layer in which information can be recorded by applying a light beam so as selectively to alter the light absorption spectrum, characterised in that said layer includes at least two compounds having different sets of photochromic characteristics permitting recording reading and erasing of information independently according to said respective sets of characteristics.

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FIG. 1 (a)

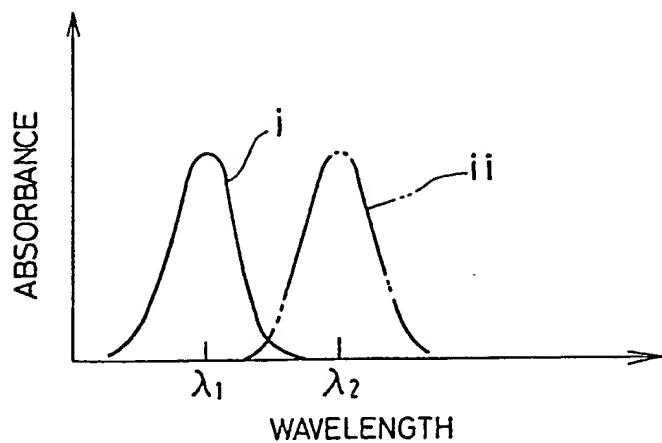


FIG. 1 (b)

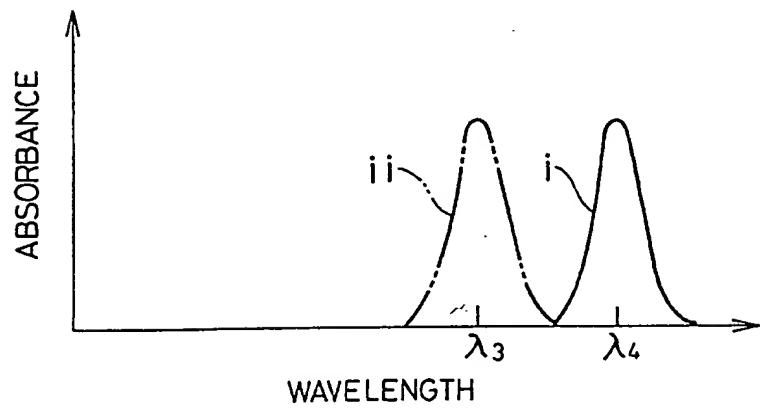


FIG. 1 (c)

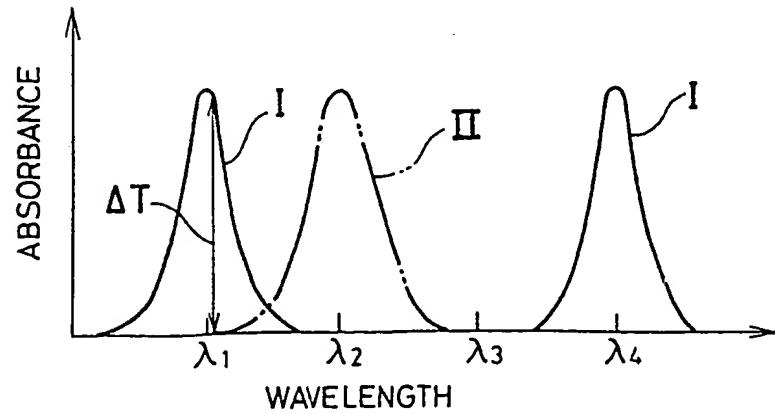


FIG.1(d)

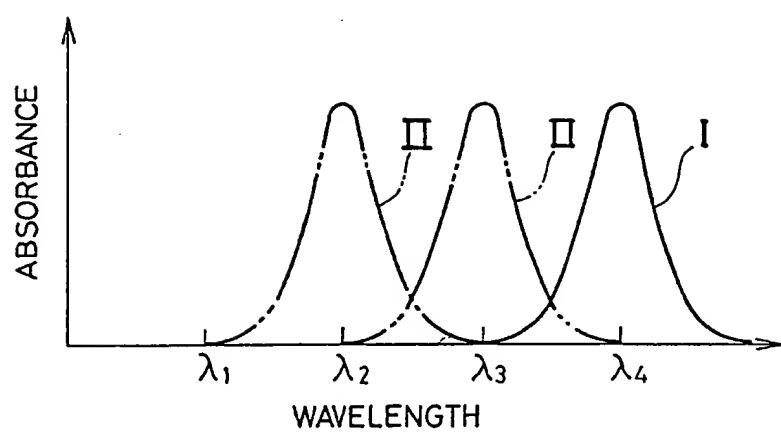


FIG. 2

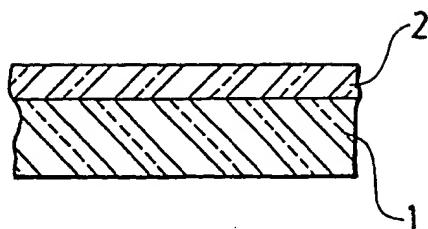


FIG. 3(a)

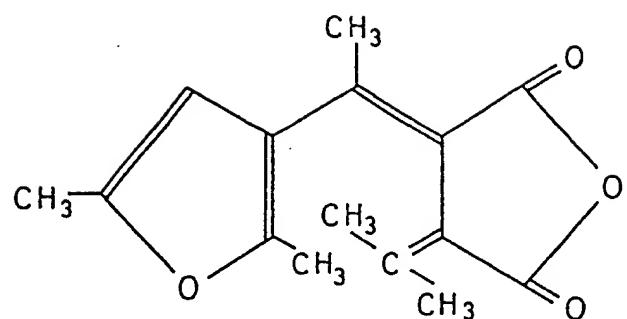


FIG. 3(b)

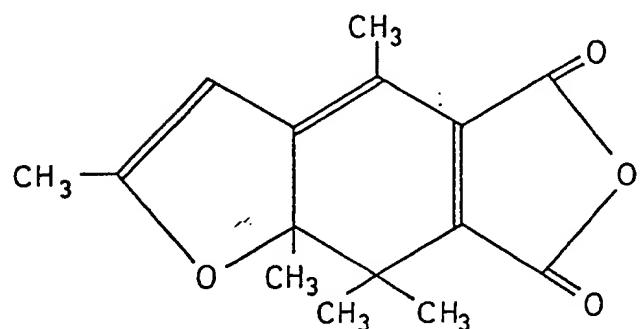
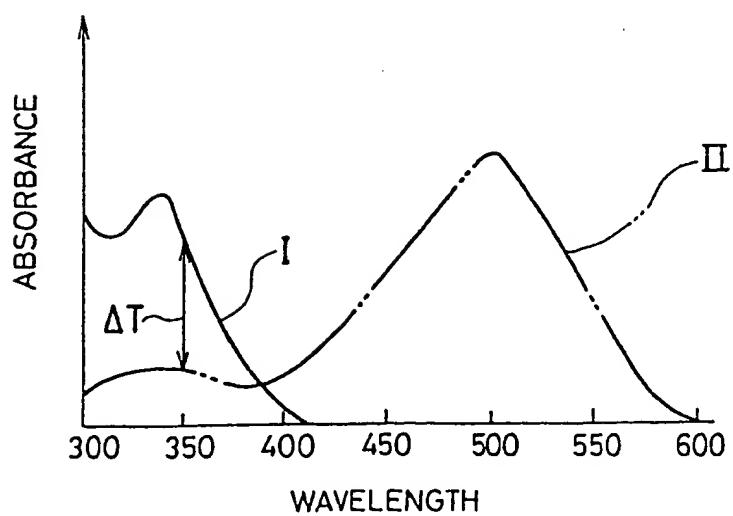


FIG. 4





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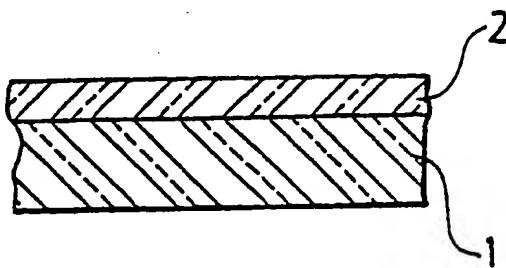
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(54) Optical recording medium and the method of recording, reading, and erasing information using it.

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(57) The invention provides an optical recording medium (2) and a method of recording, reading, and erasing information to an optical recording medium, where information is recorded, read, and erased to the recording medium by applying beams projected from a light source capable of varying wavelength of beams. The recording medium contains at least two kinds of organic compounds each presenting photochromic phenomenon and being dispersed in binder. By projecting beams onto the optical recording medium, recording, reading, and erasure of information making use of a photochromic phenomenon can be executed independently against each organic compound dispersed in the recording medium. As a result, the optical recording medium promotes to increase the information recording density in proportion to the number of the kind of organic compounds.

FIG. 2





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 30 8018

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-193931 (MATSUSHITA) * claims 1-11; figures 1-4 *	1-3, 7, 8, 12, 13	G11B7/24 G11B7/00
A	TECHNISCHE RUNDschAU. vol. 79, no. 26, 26 June 1987, BERN CH pages 70 - 77; Günther Kämpf: "Optische Datenspeicher in der Informationstechnik" * page 73, middle column, paragraph C - page 75, right-hand column, line 34; figures 7, 8 *	1, 4	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 175 (P-707)(3022) 25 May 1988, & JP-A-62 287246 (NIPPON TELEGR & TELEPH CORP.) 14 December 1987, * the whole document *	1, 3	
D,A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 6 (P-653)(2853) 09 January 1988, & JP-A-62 165751 (MITSUBISHI ELECTRIC CORP) 22 July 1987, * the whole document *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G11B
<p>The present search report has been drawn up for all claims</p>			
2	Place of search BERLIN	Date of completion of the search 19 JULY 1990	Examiner BERNAS Y.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			